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Proposed Risk Reduction Plan for Diesel-Fueled Engines and Vehicles

California Environmental Protection Agency

Air Resources Board

Mobile Source Control Division
Stationary Source Division

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I. EXECUTIVE SUMMARY

This draft plan is being made available for public comment. Staff intends to address the comments received and update this plan as appropriate. The plan will be presented to the Air Resources Board (ARB or Board) at its public meeting in September. Upon approval of a plan, ARB staff will begin its formal regulatory process in which each of the individual measures identified in the plan will go through a normal regulatory development process. Each regulation developed through this process will be brought to the Board for consideration at public hearings.

Because of the high health risks posed by exposure to diesel PM, the ARB staff is recommending a comprehensive program to further reduce emissions and resultant health risks associated with emissions of diesel PM. This effort builds upon existing regulations and other initiatives underway to reduce diesel PM emissions. None of the recommended measures will result in an increase in nitrous oxide (NOx) emissions above applicable NOx engine or vehicle certification levels. This comprehensive program consists of:

1. Developing additional regulatory emission standards for all new on-road, off-road, and stationary diesel-fueled engines and vehicles that will reduce diesel PM emissions by an overall 90 percent from current levels;
2. Developing retrofit requirements for existing on-road, off-road, and stationary diesel-fueled engines and vehicles that will significantly reduce diesel PM emissions from these engines; and
3. Developing requirements to significantly reduce the sulfur content of diesel fuel so that on-road, off-road, and stationary diesel-fueled engines will be able to use the low-sulfur diesel fuel needed by advanced diesel PM control technology.

The comprehensive program outlined above addresses diesel-fueled engines and vehicles. There are currently some cleaner alternatives to diesel-fueled engines and vehicles, e.g. electrification and compressed natural gas. These alternatives will be considered during the next step of the risk management process, when the recommended measures are developed into regulations.

The projected benefits associated with the full implementation of this plan are reductions in diesel PM emissions and associated risks of 75 percent by 2010 and 85 percent by 2020. Further, the measures recommended in the diesel RRP will have a great impact on reducing the localized risks from activities where the operation of diesel-fueled engines or vehicles could expose nearby residences to elevated diesel PM concentrations and resultant cancer risks. In addition to cancer risk reduction, there are other benefits associated with reducing diesel PM emissions. These include increased visibility; less material damage due to “soiling” of surfaces with diesel PM; and decreased incidences of non-cancer health effects, such as diesel PM induced bronchitis.

II. BACKGROUND

The public's exposure to toxic air contaminants (TACs) is a significant issue in California. In 1983, the California Legislature enacted a program to identify the health effects of TACs and to reduce exposure to these contaminants to protect the public health (Assembly Bill (AB) 1807: Health and Safety Code sections 39650-39674). The Legislature established a two-step process to address the potential health effects from TACs. The first step is the risk assessment (or identification) phase. The second step is the risk management (or control) phase of the process.

In August 1998, the ARB identified diesel PM as a TAC. This marked the completion of the identification phase of the process to address the adverse health effects due to the toxicity of diesel exhaust emissions.

This report, referred to as the Diesel Risk Reduction Plan or Diesel RRP, is the first formal product of the risk management phase of the AB 1807 process. This report presents information that identifies the available options to reduce diesel PM, and identifies recommended control measures to achieve further reductions. The recommended control measures would be developed as mobile source regulations or stationary source airborne toxic control measures (ATCMs).

The next step in the AB 1807 process, following approval of this report, is the development of the specific ATCMs and fuel or vehicular emissions regulations designed to reduce diesel PM emissions from diesel-fueled engines and vehicles. The goal of each regulation is to reduce diesel PM to the greatest extent feasible. These regulations must be technically feasible and be cost-effective. In developing rules to implement the Diesel RRP, the staff will consider the availability and cost of engine modifications, add-on control technology, changes in fuel parameters, and alternative methods of performing the function of the diesel engine application. Thus, while most of the Board's regulatory activities will be focused on emission controls that can be added to or built into diesel fueled engines, staff will also consider alternative "non-diesel" technologies (e.g., electrification and compressed natural gas (CNG)) as possible control options for reducing diesel PM emissions.

ARB staff will develop the ATCMs and regulations with full public involvement. Draft versions of the ATCMs and regulations will be presented to the public for review and comment, and a final draft version will presented to the Board for approval. Public outreach is an essential element in the development of any ATCM or regulation to ensure that the ARB efforts are cost-effective and appropriately balance public health protection and economic growth.

As part of the identification process, the Office of Environmental Health Hazard Assessment (OEHHA) evaluated the potential for diesel exhaust to affect human health. The OEHHA found that exposures to diesel PM resulted in an increased risk of cancer and an increase in chronic noncancer health effects including a greater incidence of cough, labored breathing, chest tightness, wheezing, and bronchitis. The OEHHA estimated that the cancer risk from exposure to diesel PM in concentrations of one microgram per cubic meter ranged from 130 to 2400 excess cancers per million. The Scientific Review Panel (SRP) approved the OEHHA's determinations concerning health effects and approved range of risk for particulate matter from diesel-fueled engines. The SRP concluded that a value of 300 excess cancers per million, per microgram per cubic meter, was a reasonable point estimate of unit risk of diesel PM.

The OEHHA also concluded that exposure to diesel PM in concentrations exceeding 5 micrograms per cubic meter can result in a number of long-term (chronic) noncancer health effects including greater incidence of cough, phlegm, and bronchitis. The 5 microgram per cubic meter value is referred to as the Chronic Reference Exposure Value (REL) for diesel PM. The SRP supported the OEHHA's conclusion and noted that the REL may need to be lowered further as more data emerge on potential adverse noncancer effects of diesel PM.

As part of its formal identification of diesel PM as a TAC, the Board approved the OEHHA and SRP's conclusions and directed the ARB staff to begin the risk management process. The staff was directed to develop control measures to reduce both diesel PM and other potentially harmful pollutants. The staff was also directed to form a diesel risk management working group to advise the staff during its risk management efforts. This working group, the Advisory Committee and subcommittees, are discussed in the next section.

A. How is this report structured?

This report consists of a main report and appendices that summarize and discuss the proposed risk reduction plan for the control of risk from diesel PM.

The main report provides the following information:

- defines the term "diesel-fueled engine" and identifies the categories of diesel-fueled engines and vehicles evaluated in this report;
- summarizes current regulations that address diesel PM emissions from diesel-fueled engines and vehicles;
- presents diesel PM emission inventory estimates, estimated ambient concentrations, and associated cancer risk information for the years 1990, 2000, 2010, and 2020;
- presents current near-source diesel PM emissions exposure and cancer risk estimates;
- discusses available diesel PM emissions control technology options;
- present's ARB staff's recommendation, based upon the above information, to further control diesel-fueled engines and vehicles;

- estimates the reduction in diesel PM emissions, exposure, and risk by 2010 and 2020 that could be achieved if all recommended measures were implemented; and
- recommends specific measures to be developed to further reduce diesel PM emissions from diesel-fueled engines and vehicles.

Appendix I is a list of terms, definitions and acronyms used in both the main report and appendices. Appendix II is a report on the need for further regulation of stationary and portable diesel-fueled engines. Appendix III is a report on the need for further regulation of mobile on-and off-road diesel-fueled engines (excluding portable equipment which is addressed in Appendix II.) Appendix IV is a report on the need for further regulation of diesel fuel. Appendix V is a summary of existing regulations addressing diesel-fueled engines, vehicles, and diesel fuel. Appendix VI is a discussion of the methodology for estimating the ambient concentrations of diesel PM emissions from diesel-fueled engines and vehicles. Appendix VII is a discussion of risks associated with typical activities where diesel-fueled engines and vehicles are used (risk characterization scenarios). Appendix VIII is Health and Safety Code Section 39665, which identifies the requirements this report must meet. Appendix IX is a discussion of diesel PM control technologies.

B. What does this report contain, and how was it developed?

In accordance with California Health and Safety Code Section 39665 (see Appendix VIII), this report includes the following information:

- number (population) and categories of diesel-fueled engines and vehicles;
- consideration of all past and current measures for reducing diesel PM;
- emissions and associated ambient and near-source risk levels for diesel PM;
- available technologies for reducing diesel PM;
- initial estimates for the costs of reducing diesel PM;
- alternative methods of emission reductions;
- recommended measures to be developed to reduce emissions and risk;
- potential adverse health, safety, or environmental impacts from implementation of the recommended measures; and
- impact of the recommended measures on diesel PM emissions and risk.

To ensure full opportunity for public consultation and input in developing this report, an Advisory Committee was created to serve as a forum for on-going communication, cooperation, and coordination in identifying opportunities to reduce diesel PM emissions. The Advisory Committee consists of the Stationary Source, Fuels, Mobile Source/Alternative Strategies, and Risk Management subcommittees. The Advisory Committee and each of the four subcommittees include representatives from industry, local districts, environmental organizations, ARB, the United States Environmental Protection Agency (U.S. EPA), and the public.

ARB staff will be presenting this document to each of the four subcommittees and the Advisory Committee for review and comment. Comments will be carefully considered, and the report will be revised as appropriate.

The revised report will then be released for review and comment by all interested parties. Again, comments both written and oral, will be carefully considered and the document will be revised as appropriate.

III. DIESEL-FUELED ENGINES: DEFINITION AND USES

A. How is "diesel-fueled engine" defined?

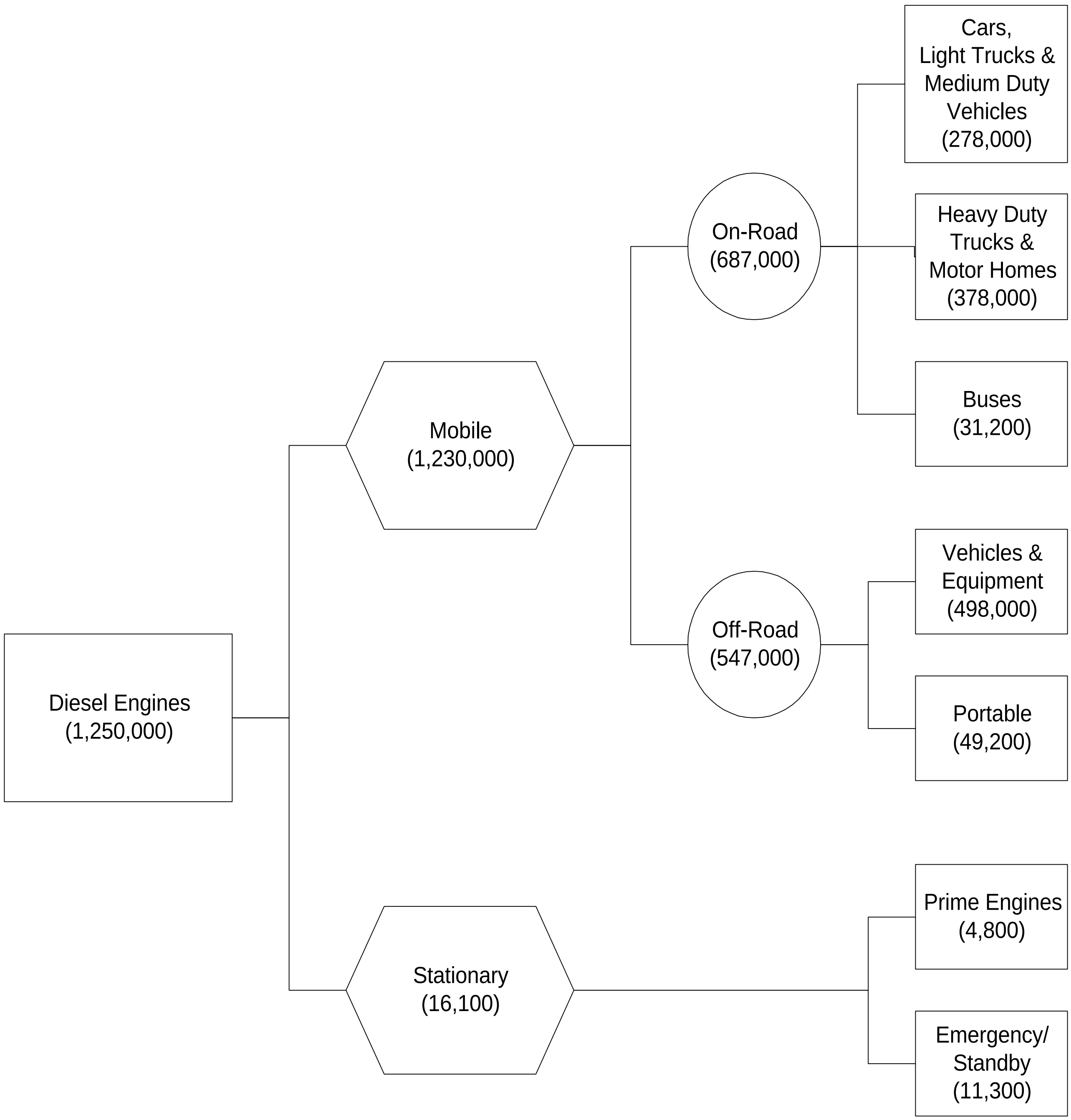
For purposes of this report, a diesel-fueled engine is defined as any internal combustion, compression-ignition (diesel-cycle) engine. It is generally assumed that the engine will be using diesel fuel. However, diesel-cycle engines using alternative fuels or fuel reformulation (e.g., jet fuel, biodiesel, CNG, and diesel/water mixtures) will be addressed during the development of each specific ATCM or regulation.

B. What categories of diesel-fueled engines and vehicles were evaluated in this report?

Staff attempted to address all diesel-fueled engines in California. Figure 1[1] identifies the specific categories and the current population of diesel-fueled engines and vehicles evaluated in this report. The following paragraphs provide a brief description of each category. Detailed descriptions can be found in Appendix II for Stationary Engines and in Appendix III for Mobile Engines.

[1] The off-road vehicle population estimate does not include locomotives, but does include military tactical support equipment. The heavy duty trucks and motor homes category includes approximately 36,000 vehicles not registered in California.

Figure 1: Diesel-Fueled Engines and Vehicle Categories (2000)



C. What are mobile engines?

Mobile engines can be divided into two categories: on-road vehicles and off-road engines and vehicles.

On-Road Vehicles: Diesel-fueled, or compression-ignition, engines are used in every category of on-road vehicles except motorcycles, and include light to heavy-duty trucks, school buses, urban buses, and passengers vehicles. In California, the majority of on-road diesel-fueled engines are found in the heavy-duty vehicles with a gross vehicle weight rating (GVWR) ranging from 14,000 pounds to 33,000 pounds. There are approximately 700,000 on-road diesel-fueled vehicles currently in use in California.

Off-Road Engines and vehicles: Diesel-fueled off-road engines comprise over 100 individual off-road vehicle and equipment types classified into 17 equipment categories. Engine sizes range from under 15 horsepower to over 10,000 horsepower. These equipment categories include agriculture, airport ground support, construction and mining, commercial, industrial, logging, transportation-refrigeration units, lawn and garden, commercial marine vessels, pleasure craft, and locomotives. Many of the off-road categories contain equipment types that are classified as portable (equipment of 25 horsepower or greater that is designed and capable of being carried or moved from one location to another.) There are approximately 550,000 off-road diesel-fueled engines and vehicles currently in use in California. A more detailed breakdown is presented in Appendix III.

D. What are stationary engines?

Stationary engines can be divided into two categories: emergency/standby engines and prime engines.

Emergency/standby engine: Emergency standby engines are typically used for emergency back-up electric power generation or the emergency pumping of water. Sizes range from 50 to 6,000 horsepower, depending on the needs of the user. Emergency standby engines make up about 70 percent of the total number of stationary engines throughout the State. Several local air pollution control and air quality management districts (districts) have in place internal combustion engine rules that regulate NOx and CO emissions, but not PM. However, most districts currently exempt emergency standby engines from complying with the requirements of these rules and do not require these engines to obtain a permit to operate. There are over 10,000 diesel-fueled emergency/standby engines in use in California.

Prime Engines: Prime engines are stationary engines that are not used in an emergency back-up or standby mode. Examples include diesel-fueled engines that are used to power compressors, cranes, generators, pumps, and grinders. Prime engines make up about 30 percent of the total stationary engine inventory throughout the State.

Of the prime engines operating throughout the State, about 70 percent are agricultural irrigation pump engines. There are approximately 5,000 diesel-fueled prime engines currently in use in California.

IV. SUMMARY OF EXISTING AND PROPOSED REGULATIONS

The ARB has the responsibility for control of emissions from mobile sources. The local air districts have the primary responsibility for control of air pollution for all sources, other than emissions for mobile sources. The South Coast AQMD has the authority to require fleets of 15 or more vehicles to purchase clean vehicles when adding or replacing vehicles, authority which they have recently exercised.

The federal Clean Air Act Amendments of 1990 (CAA) preempt state and local authority from the control of emissions from new farm and construction equipment under 175 horsepower and from new locomotives or locomotive engines (CAA Section 209(e)(1)(A)); only the U.S. EPA has the authority to establish emission standards for those engines. Because of the preemption, significant emissions of diesel PM are beyond the ARB's authority to regulate. Preemption, however, does not apply to other categories of new engines or to existing farm and construction engines that are in service, so operational and other in-use requirements fall with state and local authority.

The CAA also requires California to receive authorization from U.S. EPA for controls over the non-preempt off-road sources (CAA section 209(e)(2)(A)). Overall these provisions make the U.S. EPA an important partner in control of emissions from off-road engines.

The following sections briefly describe the existing federal, state, and local programs that currently apply to diesel-fueled engines and vehicles operating in California. A more detailed summary of the statutes and regulations may be found in the tables in Appendix V.

A. What current federal, state, or local regulations address diesel PM emissions from mobile diesel-fueled engines?

Virtually all new diesel-fueled on-road and off-road motor engines and vehicles sold in California are required to meet both federal and state emission certification requirements. Preempted engines, as noted above, must meet only the federal requirements. In most cases, California's motor vehicle and diesel-fueled engine programs are designed to be consistent with the federal programs. To ensure the engines operate at their certification standard levels, California has implemented Heavy-Duty Vehicle Inspection and Periodic Smoke Inspection Programs to reduce excessive smoke emissions and tampering with on-road diesel-fueled vehicles over 6,000 pounds gross vehicular weight. In addition to certification standards non-regulatory strategies, which include incentives and voluntary agreements with vehicle and engine manufacturers, have also been implemented in California to accelerate reductions in certain criteria pollutants.

B. What current federal, state, or local regulations address diesel PM emissions from stationary and portable diesel-fueled engines?

In California, the local air pollution control and air quality management districts establish rules and regulations for controlling emissions from new and existing stationary and portable sources of air contaminants. These rules and regulations address both criteria and toxic air contaminant emissions.

Districts preconstruction and operating permit programs implement the local, State, and federal air pollution control requirements applicable to new or modifying sources of air pollution. A new or modified source located in a nonattainment area must apply the Lowest Achievable Emission Rate control technology to minimize emissions, and they must "offset" the remaining emissions with reductions from other sources. A new or modifying source located in an attainment or unclassified are must apply the Best Available Control Technology and meet additional requirements aimed at maintaining the region's clean air. In addition, "major sources" of air pollution must obtain federal Title V operating permits that govern continuing operation.

Many districts have also adopted, pursuant to the California Health and Safety Code, Reasonably Available Control Technology/Best Available Retrofit Control Technology requirements that apply to existing sources located in nonattainment, attainment, and unclassified areas. These requirements are also implemented through the district's permit program.

Portable equipment is regulated by both the ARB and districts. Pursuant to State law, the ARB has established the Portable Equipment Registration Program (PERP) which is a voluntary program for the registration and regulation of portable engines and associated equipment. Several districts have implemented similar registration programs. Portable equipment not registered through the ARB or a local district maybe subject to district stationary source permit requirements, depending on the size of the engine. In addition, the U.S. EPA and ARB have established engine certification standards for new off-road engines (of which portable engines are a subset). These engines are available for use in portable equipment.

C. What current federal, state or local regulations address diesel fuel formulation?

Current federal U.S. EPA regulations establish fuel registration and formulation requirements. All diesel fuels and all additives for on-road motor vehicles are required to be registered with the U.S. EPA. The ARB has established California fuel formulation requirements, applicable to all motor vehicles, that either meet or exceed existing federal formulation requirements. In addition, ASTM D 975 specifies standards which diesel fuels should meet to ensure safety, reliability, and performance. Generally, alternative diesel fuels do not meet all of the ASTM specifications.

Since 1993, the regulatory sulfur content limit of California diesel has been 500 parts per million by weight (ppmw.) However, the average sulfur content of complying fuel formulations currently being sold in California is estimated at 140 ppmw.[2] Although stationary engines are not required to use fuel that meets California Air Resources Board diesel (CARB diesel) formulation requirements, virtually all use complying fuel because of California's single fuel distribution network. Also, districts have the authority to establish formulation requirements for fuels to be used in these engines. To date, several districts have established diesel-fueled engine best available control technology requirements specifying the use of low-sulfur diesel fuel. Portable engines registered under ARB's Statewide Portable Equipment Registration program are required to use CARB diesel. Beginning July 1, 2002, medium and larger transit agencies must use diesel fuel with a sulfur content no greater than15 ppmw in all diesel buses.

V. EMISSION INVENTORY AND RISK

This section summarizes the statewide diesel PM emissions inventory from diesel-fueled engines and provides ambient and near-source cancer risk estimates for those emissions. A detailed description of how the inventory, ambient concentration, and ambient risk values listed in Tables 1 through 5 of this chapter were determined is presented in Appendix VI.

A. What are the estimated diesel particulate matter emissions for 1990, 2000, 2010, and 2020?

Table 1 lists the estimated for the statewide diesel PM emissions inventory from diesel-fueled engines and vehicles for 1990. Tables 2, 3, and 4 provide similar estimates for 2000, 2010, and 2020. The relative contribution of the major subcategories of engines and vehicles that comprise the stationary and mobile categories are also shown. All tables take into account reductions due to both federal and state regulations in effect at the time of the inventory estimate. These estimates do not include proposed recommended measures discussed in Chapter VIII.

[2] 141 ppmw is the volume-weighted average determined by the California Energy Commission's 1997 California refiner survey (See Appendix IV)

Table 1: Estimated Statewide Diesel PM Emissions Inventory – Diesel-Fueled Engines and Vehicles (1990)

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,600	400	0.9
Emergency Stand-by	10,200	124	0.3
MOBILE			
On-road	606,700	18,400	39.7
Off-road (Excluding Portable Equipment)	476,300	25,300	54.5
Portable	47,600	2,200	4.7
TOTAL	**1,145,300**	**46,400**	**100.0**

Table 2: Estimated Statewide Diesel PM Emissions Inventory – Diesel-Fueled Engines and Vehicles (2000)

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,800	420	1.5
Emergency Stand-by	11,300	138	0.5
MOBILE			
On-road	687,200	7,500	26.7
Off-road (Excluding Portable Equipment)	498,200	18,600	66.4
Portable	49,200	1,400	5.0
TOTAL	**1,250,700**	**28,000**	**100.0**

Table 3: Estimated Statewide Diesel PM Emissions Inventory – Diesel-Fueled Engines and Vehicles (2010)

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,400	360	1.6
Emergency/Standby	12,300	143	0.6
MOBILE			
On-road	643,900	5,300	23.2
Off-road (Excluding Portable Equipment)	521,300	15,900	69.7
Portable	53,600	1,100	4.8
TOTAL	**1,235,500**	**22,800**	**100.0**

Table 4: Estimated Statewide Diesel PM Emissions Inventory – Diesel-Fueled Engines and Vehicles (2020)

Category	Engine Population	Diesel PM (tons per year)	% of Total Diesel PM Emissions
STATIONARY			
Prime	4,400	350	1.9
Emergency/Standby	13,200	149	0.8
MOBILE			
On-road	610,200	4,900	25.9
Off-road (Excluding Portable Equipment)	527,800	12,800	67.7
Portable	55,200	660	3.5
TOTAL	**1,210,800**	**18,900**	**100.0**

The current inventory of diesel PM emissions in Table 2 shows that there are about 28,000 tons per year of diesel PM that can potentially be reduced from a variety of sources. The inventory also shows that the sources are numerous, with over 1.25 million diesel-fueled engines operating statewide. Comparing the statewide diesel PM emissions in Table 1 (1990) and Table 2 (2000), shows that significant progress has been made to reduce diesel PM emissions in California.

The bulk of the 40 percent decrease in diesel PM emissions from 2000 to 2020 is due to currently adopted on-road standards and fleet turn-over as new vehicles with controls replace older vehicles with little or far less effective controls. Proposed federal standards for diesel-fueled engines are not considered in this inventory, but would reduce total diesel PM by approximately 20 percent by 2020. Some reduction in diesel PM emissions is due to a slight decrease in engine population.

B. What are the estimated statewide cancer risks associated with diesel PM emissions?

Table 5 lists the ARB staff's estimates for statewide population-weighted annual outdoor average diesel PM concentrations and corresponding excess cancer risks for the years 1990, 2000, 2010, 2020 resulting from diesel PM emissions. These estimates are based on the emission inventory estimates presented in Tables 1 through 4.

The Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant, Appendix III, Part A, Exposure Assessment[3] (ID Report) reported the statewide population–weighted annual outdoor average diesel PM concentration as 3.0 µg/m^3 for 1990. The ARB staff reviewed studies conducted in the San Joaquin Valley, South

[3] As approved by the Scientific Review Panel on April 22, 1998.

Coast, and San Jose to obtain more complete PM_{10} ambient data. This information, along with routinely collected ambient PM_{10} monitoring network data and the 1990 PM_{10} emissions inventory, were used in a receptor model to estimate the statewide outdoor concentration of diesel PM in 1990.

We estimated the statewide outdoor concentration of diesel PM for 1990, 2000, 2010, and 2020 by assuming that the ambient concentration is proportional (linearly) to the statewide emissions. The ratio of the ambient concentration to statewide emissions was assumed to remain constant for the years 1990, 2000, 2010, and 2020. For 1990, this ratio was determined by using the ambient concentration from the ID report (3.0 $\mu g/m^3$) and the statewide emission estimate for 1990 from Table 1 (46,400 TPY). Using the 1990 ratio and the statewide emissions estimates for 2000, 2010, and 2020 from Tables 2, 3, and 4, the ambient concentration estimates for 2000, 2010, and 2020 were estimated. In all cases, the risk was estimated by multiplying the statewide ambient concentration by the unit risk factor of 300 excess cancers per million per microgram per cubic meter of diesel PM.[4]

Table 5: Statewide Population-Weighted Annual Outdoor Average Diesel PM Concentration and Cancer Risk for 1990, 2000, 2010, and 2020

	1990	2000	2010	2020
Concentration ($\mu g/m^3$)	3.0	1.8	1.5	1.2
Cancer Risk (excess cancers/million)	900	540	450	360

The ID Report provided estimates of indoor and total exposure to diesel PM. Applying the 1990 ratio to the estimated population-weighted annual outdoor average diesel PM concentrations for 2000, 2010, and 2020 results in the following indoor exposure estimates, respectively: 1.2 μ/m^3 , 1.0 μ/m^3, and 0.8 μ/m^3 . Total exposure estimates for 2000 and 2010 are 1.3 μ/m^3 , 1.1 μ/m^3, and 0.84 μ/m^3 . This information, along with the estimated cancer risk values, is summarized in Table 6.

4 The full range of risk identified by the SRP is 130 to 2400 excess cancers per million per microgram per cubic meter of diesel particulate matter. The 300 value was identified by the SRP as a reasonable estimate of unit risk.

Table 6: Estimated Exposure of Californians to Diesel PM for 2000, 2010 and 2020

	Estimated Average Air Exposure Concentration – 1990 μg/m³	1990 Ratio	Estimated Average Air Exposure Concentration (μg/m³) and Risk (excess cancers/million)					
			2000		2010		2020	
			Conc.	Risk	Conc.	Risk	Conc.	Risk
Outdoor Ambient Estimate	3.0		1.8	540	1.5	450	1.2	360
Total Indoor Exposure Estimate	2.0	2.0/3.0	1.2	360	1.0	300	0.8	240
Total Exposure Estimate	2.1	2.1/3.0	1.3	390	1.1	315	0.84	252

C. How much of the estimated statewide cancer risk level from air toxics is due to diesel PM?

To provide a perspective on the contribution that diesel PM has on the overall statewide average ambient air toxics cancer risk, ARB staff evaluated risks from other compounds using data from ARB's ambient monitoring network. ARB maintains a 21 site air toxics monitoring network which measures outdoor ambient concentration levels for approximately 60 air toxics.

Table 7 shows the potential cancer risk from the top ten inhalation risk contributors that the State of California has identified as toxic and routinely monitors. The diesel PM values are calculated based on the procedure discussed in the previous section. The risk values for the other compounds are based on the annual average concentration (determined from ambient monitoring) multiplied by the unit risk factor for each compound. Table 7 also shows that of the top ten identified and monitored compounds, diesel PM contributes the most to inhalation health risk.

Table 7: Estimated Statewide Average Potential Cancer Risk from Outdoor Ambient Levels of Air Toxics for the year 2000

Compound	Potential Cancer Risk[1,2] Excess Cancers/Million	Percent Contribution to Total Risk
Diesel Exhaust PM_{10}	540	71.2
1,3-Butadiene	74	9.8
Benzene	57	7.5
Carbon Tetrachloride	30	4.0
Formaldehyde	19	2.5
Hexavalent Chromium	17	2.2
para-Dichlorobenzene	9	1.2
Acetaldehyde	5	0.7
Perchloroethylene	5	0.7
Methylene Chloride	2	0.3
TOTAL	**758**	**100**

1. Diesel exhaust PM_{10} potential cancer risk based on 2000 emission inventory estimates presented in Table 5. All other potential cancer risks based on air toxics network data. Used 1997 data for para-Dichlorobenzene. Used 1998 monitoring data for all others.
2. Assumes measured concentrations are equivalent to annual average concentrations and duration of exposure is 70 years, inhalation pathway only.

The South Coast Air Quality Management District also conducted a study of air toxics in the South Coast Air Basin (Multiple Air Toxics Exposure Study II (MATES-II)) in 1998 and 1999. Results from MATES-II indicate that the average basin wide cancer risk from diesel PM accounts for 1000 excess cancers per million, or 71 percent of the 1400 excess cancers per million from exposure to air toxics measured in the South Coast Air Basin.

Independent of the MATES II study, ARB staff's findings are consistent with the MATES-II study in that diesel PM is a major contributor to ambient risk and accounts for approximately 70 percent of the ambient air toxics risk. Our analysis also indicates that average ambient concentrations of air toxics are higher in the South Coast Air Basin then elsewhere, resulting in higher estimates of risk, as was shown in the MATES II study. Staff concludes that reducing the risk from diesel PM is an essential element in reducing the public's overall ambient exposure to air toxics.

D. What are the cancer risks associated with some typical activities where diesel-fueled engines are used?

ARB staff estimated the range of potential cancer risks from seven common activities or situations where the operation of diesel-fueled engines could expose nearby residences to diesel PM concentrations higher than average regional concentrations. The specific situations investigated included idling school buses, truck stops, freeways, emergency and standby diesel engine operations, prime engine operations, and warehouse distribution center operations. Figure 2 shows the range of potential cancer risk, above background levels associated with each type of activity. Each cancer risk value identified in Figure 2 represent the cancer risk associated with that activity only.

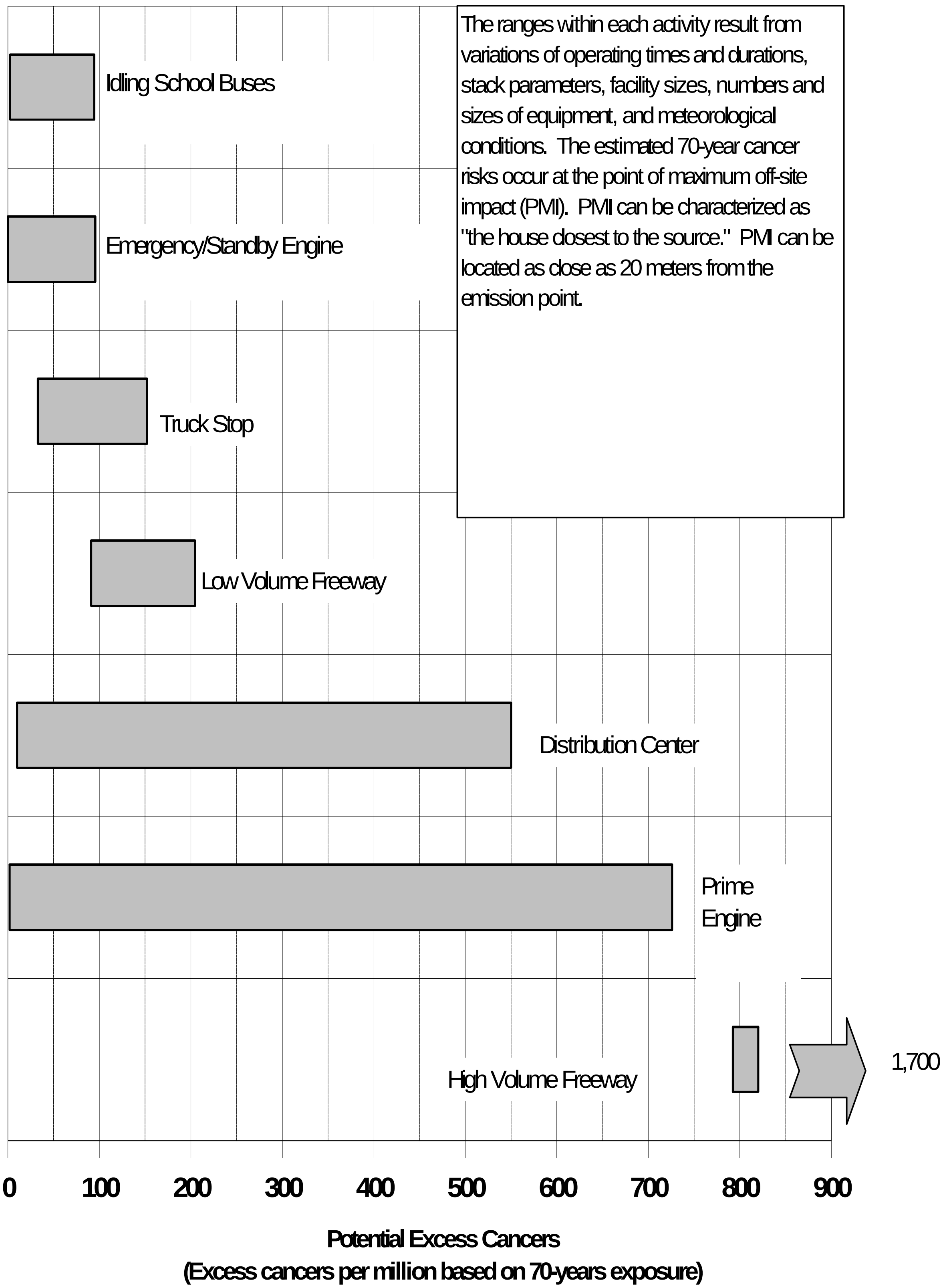
The risk estimate for each activity does not account for the risk from any other diesel-fueled engines or vehicles. For more detailed information regarding each activity, see Appendix VII.

Risk is estimated by multiplying the modeled or measured concentration of a toxic compound by the carcinogenic potency value, also known as the unit risk factor. The unit risk factor is defined as the estimated probability of a person contracting cancer as a result of constant exposure to an ambient concentration of 1 $\mu g/m^3$ over a 70 year lifetime. Seventy year lifetime is the standard used for evaluating air toxic risk in California.

We expect the estimated 70-year cancer risk range for each of these activities would fall within the ranges in Figure 2. Each range assumes a 70-year exposure to diesel PM emissions at current levels, and uses the Scientific Review Panel's (SRP) recommended diesel PM unit risk factor of 300 excess cancers per million per microgram per cubic meter of diesel PM. The ranges within each activity result from variations in assumptions of operating times and durations, stack parameters, facility sizes, numbers and sizes of equipment, and meteorological conditions. For example, in the Idling School Buses scenario the activity ranged from five buses idling two minutes each twice per day to 20 buses idling 15 minutes each twice per day for 180 days per year. The estimated 70-year cancer risks in Figure 2 occur at the point of maximum off-site impact (PMI). PMI can be characterized in layman's terms as "the house closest to the source," the PMI can be located as close as 20 meters from the emission point. Exposures and risks for residences further removed from the activity will be less. For example, the PMI cancer risk from the Low-Volume Freeway scenario is estimated to be 200 excess cancers per million for residences located 20 meters away. A residence located 500 meters away, exposed to diesel PM emissions from that same activity, is esimated to be exposed to a cancer risk of 30 excess cancers per million.

Figure 2 shows that each of the investigated activities can lead to significant increases in risk under certain circumstances. The risk associated with these activities, combined with the high statewide ambient risk levels reported earlier, provide additional rationale for the staff's conclusion that all categories of diesel-fueled engines should be subject to further control requirements. Localized risks to individuals living near a diesel-fueled engine can be significantly higher than the statewide ambient outdoor risk estimates.

Figure 2: Cancer Risk Range of Activities Using Diesel-Fueled Engines



VI. CONTROL TECHNOLOGY AND FUEL OPTIONS

A. Has ARB identified control technology options that can further reduce diesel PM emissions from diesel-fueled engines and vehicles?

Yes. The ARB has evaluated various types of control options identifying the control efficiency, description of technology, cost, and source test data. Technical evaluations of the control technologies, including summaries of the available emission test information, are included in Appendix IX. Because emission test information was deemed essential for a thorough evaluation of diesel PM control technologies, detailed technical evaluations were not performed where the technology proponent did not provide adequate emission test information. The most effective control technologies evaluated by ARB staff are catalyst-based diesel particulate filters (catalyst-based DPFs).

Catalyst-based DPFs use catalyst materials to reduce the temperature at which collected diesel PM oxidizes. The catalyst material can either be directly incorporated into the filter system, or can be added to the fuel as a fuel-borne catalyst (FBC-DPF). Used with very low-sulfur (<15 ppmw sulfur) diesel fuel, catalyst-based DPFs can reduce diesel PM emissions by over 90 percent.

Table 8 provides a description and range of control efficiencies catalyst-based DPFs and new diesel-fueled engines. The control efficiency information is based on available test information summarized in Appendix IX. As shown, the range of control efficiencies for catalyst-based DPFs used with a very low-sulfur diesel fuel is 85 to 97 percent.

Table 8: Control Technology Efficiencies

Control Technology	Diesel PM Control Efficiency	Description
Catalyst-Based DPFs / Very low-sulfur Fuel	85% - 97%	Particulate filter system where the catalyst material is either incorporated into the filter or added to the fuel; Diesel fuel has a sulfur content ≤ 15 ppmw.
New Engine	Up to 85%	Replaces existing engines with engines certified to meet ARB/U.S. EPA off-road engine emission standards.

For existing diesel engine applications, catalyst-based DPFs have been shown to be effective in reducing diesel PM emissions. In several European countries, catalyst-based DPFs have been installed on more than 6,500 buses, heavy-duty trucks, and municipal vehicles. In the United States, the application of catalyst-based DPF's is less prevalent, but several demonstration projects have been initiated. In California, diesel-fueled school buses and tanker trucks have been retrofitted with catalyzed DPFs as part of a program to evaluate the effectiveness of a refiner's low-sulfur diesel formulation. In New York, the New York City transit authority's fleet demonstration program will test the effectiveness of catalyzed DPF's on 50 diesel-fueled buses.

For new diesel engine applications, catalyst-based DPF technology is playing a key role in both establishing and complying with new more stringent diesel PM standards. The U.S. EPA recently announced its proposed regulation for heavy-duty engine and vehicle standards and highway diesel fuel sulfur control requirements. A diesel PM emission standard of 0.01 g/bhp/hr is proposed. This proposed standard is based on the anticipated emission reductions from low-sulfur diesel fuel and the use of a catalyst-based diesel particulate filter. To comply with a 2005 European Union (EU) emission standard for diesel fueled vehicles, the French automaker, Peugeot Citroen, recently unveiled a diesel PM catalyst-based DPF system which is expected to go into production in the year 2000.

B. What are the costs associated with these control technology options?

Tables 9a through 9d present information on the costs associated with applying catalyst-based DPFs[5] to stationary, off-road, and on-road diesel engines, including both retrofit and new engine applications. Table 9a provides information on the capital costs associated with retrofitting stationary diesel engines with catalyst-based DPFs. This information was obtained from representative catalyst-based DPF manufacturers and is intended to represent the range in the retail costs at this time. These cost estimates are mostly consistent with the $30 to $50 per horsepower range reported by the Manufacturers of Emission Controls Association (MECA) in “Emission Control Technology for Stationary Internal Combustion Engines” dated July 1997.

Table 9a: Stationary Engines - Current Catalyst-Based DPF Retrofit Costs

Technology	40 hp	100 hp	275 hp	400 hp	1,400 hp
Capital Cost	$1,300 - $5,000	$2,000 - $7,500	$3,500 - $9,000	$7,000 – $10,500	$30,000 - $44,000

[5] SomeCatalyst-Based -DPFs require and all Catalyst-Based DPF's will benefit from the use of very-low sulfur fuel. The incremental cost of this fuel is projected to be less than $ 0.05 per gallon and is discussed further in Appendix IV.

The costs associated with retrofitting off-road engines with catalyst-based DPFs are presented in Table 9b. This information also assumes a cost of $30 to $50 per horsepower, as reported by MECA representatives in "Exhaust Controls Available to Reduce Emissions from Non-road Heavy-Duty Engines."

Table 9b: Off-Road Engines - Current Catalyst-Based DPF Retrofit Costs

Technology	190 hp[6]	275 hp	475 hp
Catalyst-Based DPF	$5,700-9,500	$8,250-13,750	$13,500- 23,750

Table 9c provides an estimate of the current cost to retrofit on-road engines and vehicles with catalyst-based DPFs. This information assumes a cost of $10 to $20 per horsepower, as reported by MECA in "Emission Control Retrofit of Diesel-Fueled Vehicles" dated March 2000.

Table 9c: On-Road Engines - Current Catalyst-Based DPF Retrofit Costs

Vehicle Class	LHD	MHD	HHD
Average Horsepower[7]	**190 hp**	**250 hp**	**475 hp**
Capital Cost	$1,900 - $3,800	$2,500 - $5,000	$4,750 - $9,500

In contrast to the retrofit costs presented in Tables 9a – 9c, Table 9d presents the U.S. EPA's estimate of the future (2007) costs of applying catalyst-based DPFs to new on-road engines and vehicles. The U.S. EPA estimates are based on higher production volumes, and they are similar to the future cost projections presented by MECA in "Emission Control Retrofit of Diesel-Fueled Vehicles."

Table 9d: On-Road Engines - Future (2007) Catalyst-Based DPF Costs

Vehicle Class	LHD	MHD	HHD
Average Horsepower[8]	**190 hp**	**250 hp**	**475 hp**
Catalyst-Based DPF Costs[9]	$670	$890	$1,100

[6] The power range noted has been selected to facilitate comparison with on-road costs.
[7] The average horsepower was derived from the U.S. EPA's engine certification database for LHDD, MHDD, and HHDD engines for model years 1999 and 2000.
[8] The engine horsepower ranges were derived from the U.S. EPA's engine certification database for LHDD, MHDD, and HHDD engines for model years 1999 and 2000.
[9] The U.S. EPA Catalyst Based-DPF cost estimates include both fixed costs (e.g. tooling, research and development, and certification) and variable costs (e.g. hardware, assembly and markup).

There is a stark difference between the current costs associated with retrofitting existing engines and the future costs associated with applying catalyst-based DPFs to new engines and vehicles. However, because catalyst-based DPFs are an emerging technology, their costs are expected to decline as production volumes and experience increase. ARB staff expects that, over the next few years, the retrofit costs presented in Tables 9a- 9c will approach the new engine costs presented in Table 9d. As such, we believe that the application of catalyst-based DPFs will be a cost-effective approach to reducing the risks from both new and existing diesel-fueled engines and vehicles.

Notwithstanding the preceding discussion, detailed cost and cost-effectiveness analyses will be completed during the preparation of each control measure. In addition, ARB staff recognize that there may be unique situations that require a special evaluation of the feasibility and/or cost-effectiveness of applying catalyst-based DPF technology. These issues will be fully investigated and considered during the development of the specific control measures.

VII. ALTERNATIVE TECHNOLOGIES

A. What alternatives to diesel-fueled engines and vehicles exist today that would result in lower diesel PM emissions?

Diesel-fueled engines are extensively used throughout California in equipment and vehicles that provide for the transportation of goods, construction of homes, and emergency power generation. (See Chapter III for more information on the uses of diesel-fueled engines.) Diesels are the engines of choice for most “heavy-duty” applications. However, for a significant number of applications, lower PM emitting alternatives to existing diesel-fueled engines exist. As ARB staff develops the control measure recommended in this report, the feasibility and cost of these alternatives will be evaluated and considered. In most cases, it is expected that well controlled diesel engines using very low-sulfur fueled will have equivalent PM performance as benchmark gasoline or CNG fueled engines. Where this is true, it is envisioned that regulations would be structured to provide a choice of fuels. In cases where alternatively-fueled engines offer emission performance that cannot be matched by diesel-fueled engines, the feasibility and costs of setting standards based the capability of alternatively fueled engines will be assessed.

Current alternatives to diesel-fueled vehicles and equipment include:

- natural gas fueled vehicles and equipment;
- gasoline-fueled vehicles and equipment;
- electrically-powered vehicles and equipment;
- fuel cell technology; and
- other alternatively fueled (e.g., Bio-diesel) vehicles and equipment.

The next step in the AB 1807 process, following approval of this report, is the development of the specific ATCMs and regulations designed to reduce diesel PM emissions from diesel-fueled engines and vehicles. Chapter VIII identifies the specific control measures we currently recommend be developed. As part of the process in developing these recommended measures, where appropriate, the ARB staff will thoroughly evaluate available alternatives to diesel-fueled engines and diesel fuel. Criteria evaluated by the ARB staff when considering the recommendation of alternative technologies include

- reduction in emissions of air toxics;
- the availability and quality of source test information;
- cost and cost-effectiveness of the alternative technology; and
- operation or design constraints associated with the alternative

In summary, diesel-fueled engines have established themselves for a variety of reasons as the preferred power source for many functions in our industrial society. However, cleaner alternatives do exist which ARB staff will consider when developing the measures recommended in this report.

ARB staff will develop the ATCMs and regulations in an open and public process. Draft versions of ATCMs and regulations will be presented to the public for review and comment, and a final draft version will presented to the Board for approval. Public outreach is an essential element in the development of any ATCM or regulation to ensure that the ARB efforts are cost-effective and appropriately balance public health protection and economic growth.

VIII. ARB'S RECOMMENDATION

In August 1998, the ARB identified particulate matter emissions from diesel fueled engines as a TAC, and staff was directed to begin the risk management process. A working group was convened to advise the staff with its risk management efforts. Since October 1998, staff has been working with the advisory committee to develop this report on the need for further control of particulate emissions from diesel engines. Staff finds that:

1. the current inventory of diesel PM emissions, as presented in Chapter V of this report, demonstrate that stationary, and mobile diesel engines currently emit over 28,000 tons per year of diesel PM in California;
2. the current statewide population-weighted annual outdoor risk from exposure to diesel PM emissions, as presented in Chapter V of this report, is estimated at over 500 excess cancers in a million;
3. the evaluation of available diesel PM control technologies and strategies, as presented in Appendix II and Appendix IX to this report, demonstrates that technically and economically feasible diesel PM control measures are available for diesel-fueled engines and vehicles.

Therefore, we recommend that the ARB direct staff to develop measures to reduce diesel PM emissions from all diesel-fueled engines and vehicles. Measures that we recommend to be developed are presented below. None of the recommended measures will result in an increase in NOx emissions above applicable NOx emission certification levels.

The recommended measures for regulation development are discussed in sections A, B, and C below. Section D discusses the actions we believe U.S. EPA needs to pursue to support our recommendations and to reduce diesel PM emissions in California. Section E discusses possible adverse impacts associated with the recommended measures. A more detailed description of each recommended measure and the associated emission reduction, risk reduction, cost analysis, and proposed implementation date for each measure can be found in Appendices II, III, and IV.

A. What measures does ARB recommend be developed to further reduce diesel PM from mobile diesel-fueled engines and vehicles?

Table 10 summarizes the recommended measures for all mobile sources except for retrofit of off-road portable equipment, which is discussed in the next section. Together, these measures comprise a comprehensive program to be implemented in California to control and reduce cancer risk from exposure to diesel particulate matter from mobile sources. These measures are further subcategorized for on-road and off-road applications. Alternative strategy applications, which are non-regulatory, are also part of the comprehensive program. They are discussed later in this section.

As discussed in Chapter II, the recommended measures will be developed in accordance with the requirements of AB 1807. The specific control requirements of each measure will be developed in an open and public process. Details concerning each specific recommended measure, which include the cost and cost-effectiveness of controls and the availability of alternative technologies, will be explored as each recommended measure is developed.

Table 10: Recommended Measures to Reduce Diesel PM From Mobile Sources

Measures	Proposed Implementation Date	Est. PM Reduction, tons per year	Est. PM Reduction, tons per year	Est. Cost per Unit, $
On-Road Measures		**2010**	**2020**	
Supplemental test procedures HDV certification	2004	n/a	n/a	to be determined
Lower emission standards for new HDV engines	2007	1,600	3,500	670-1100
Control of emissions from existing engines (retrofit)	2001-2008	2,100	320	1900-9500
Solid waste collection vehicles	2002			
Other public HDV fleets	2002			
Other public & private HDV fleets	2003-2008			
Control of HDV in-use emissions	2005	n/a	n/a	130-150
Off-Road Measures				
Lower emission standards for new engines	2006-2008	910	3,600	1300-1800
Control of emissions from existing engines (retrofit)	2002-2008	10,800	6,800	5700-23800
Public fleets	2002-2003			
Other off-road fleets	2006-2008			
Control of in-use emissions	2006-2008	n/a	n/a	to be determined
PM standards for new diesel pleasure craft engines	2005	9	24	to be determined

On-Road

The recommended measures for diesel-fueled on-road mobile vehicles listed in Table 9 address both new and existing vehicles. For new vehicles, ARB staff is proposing that new engine diesel PM standards that will reduce diesel PM emission by at least 90 percent from the current on-road standards. This proposal is based upon U.S. EPA’s proposed heavy-duty engine and vehicle standards and highway diesel fuel sulfur control requirements rule, and the expected engine, fuel, and control technology development needed to meet the proposed standards. For existing vehicles, ARB staff is proposing diesel PM emissions be reduced, for almost all (90 percent) engines, by at least 85 percent through the addition of aftertreatment technology. In-use compliance programs will be implemented or enhanced to maintain the diesel PM emission reductions achieved through cleaner new engine standards and retrofits.

Off-Road

The recommended measures for diesel-fueled off-road engines are similar to those for on-road vehicles: more stringent diesel PM standards, aftertreatment control retrofit requirements, and in-use compliance programs. In contrast, to on-road vehicles, off-road engines are not registered by the State, although some portable engines are permitted and/or registered by local districts or the State. Therefore, to ensure the application of recommended measures such as inspection and maintenance programs, in-use compliance testing, or mandatory retrofitting of older equipment, the ARB and district staff must rely on mechanisms such as warranty registration and local operating permits.

Non-Regulatory Strategies

Non-regulatory strategies for mobile sources include guideline development, voluntary memoranda of understanding, or non-regulatory incentive programs. A variety of voluntary and incentive programs are being proposed to achieve reductions beyond those California can achieve through regulatory action. Some involve programs adopted and implemented by local air districts, others are activities for which the ARB does not currently have the authority to regulate. While pursuing these non-regulatory strategies, ARB staff will work with the appropriate regulatory agencies to support their development of regulations consistent with what we are proposing for on-road and off-road sources under our jurisdiction. The non-regulatory strategies being considered by the ARB staff include:

- ♦ implementing transportation control measures – idling restrictions;
- ♦ the voluntary retrofit of emergency vehicles;
- ♦ the voluntary application of diesel particulate filters for locomotives;
- ♦ implementing an older school bus replacement/retrofit program (2001-2002 budget item); and
- ♦ developing a memorandum of understanding (MOU) for the retrofit of airport ground support equipment.

B. What measures does ARB recommend be developed to further reduce diesel PM emissions from stationary and off-road portable diesel-fueled engines?

Table 11 summarizes the recommended measures designed to reduce diesel PM emissions from stationary and off-road portable diesel-fueled engines. The measures identified in this section are discussed in more detail in Appendix II. For new engines, the recommended control measures presented in Table 11 require the application of catalyst-based DPFs or a similar technology that will reduce diesel PM emissions by at least 90 percent from uncontrolled levels. For existing engines, staff is proposing that diesel PM emission be reduced, for almost all engines (90 percent) by at least 85 percent. Because of the variety of existing engines, as well as the multitude of applications, staff expects that no single control technology will be universally applicable to all retrofit applications. The cost per pound of diesel PM reduced reflects the predicted costs associated with purchasing, installing, and maintaining a catalyst-based DPF on each of the diesel-fueled engines addressed by the recommended measure.

Table 11: Recommended Measures to Reduce Diesel PM from Stationary and Off-Road Portable Sources

Control Measure	Proposed Implementation Date	Estimated PM Reduction 2010 (TPY)	Estimated PM Reduction 2020 (TPY)	Cost Effectiveness ($/lb.)
Stationary Engine				
New Engine Permitting	2002	33	21	37 – 72
Prime Engine Retrofit	2003	70	66	14 – 27
Emergency Backup Retrofit	2003	105	105	118 – 225
Off-Road Portable Engine Retrofit	2004 – 2005	712	252	20– 53
Agricultural Engine Retrofit	2004 – 2005	297	197	7 – 17

Stationary

The recommended measures for stationary diesel-fueled engines listed in Table 11 address both new and existing engines. For new engines, the ARB staff recommends that ARB staff develop an ATCM based on the requirements of the ARB's permitting guidance document, Risk Management Guidance for the Permitting of New Stationary Diesel-fueled Engines, (September 2000). Diesel PM emission reductions from new stationary diesel-fueled engines will be accomplished by requiring these engines to meet either specific technology requirements (i.e., stringent diesel PM engine certification levels, usage of low-sulfur diesel fuel, and application of catalyst-based DPFs); or an equally stringent performance standard. Health risk assessments will be required for engines that operate over 400 hours. (See Appendix II for a more detailed description of Guidance requirements.)

For existing prime engines and emergency standby engines, ARB staff recommends the development of ATCMs that define retrofit control requirements. As shown in Table 11, ARB staff predicts the implementation of the prime engine and emergency standby engine ATCMs by 2003 will result in diesel PM reductions of up to 70 tons and 105 tons in 2010, respectively. This represents an 85 percent reduction in diesel PM emissions from at least 90 percent of the engines in these categories. Although catalyst-based DPFs are available, for these sources, this technology may not prove to be cost-effective for all engines especially smaller engines with limited hours of operation. During the ATCM development process, the ARB staff will conduct a more detailed cost-effectiveness analysis to help in determining the appropriateness of these controls. It is anticipated that both of these ATCMs would be fully implemented prior to 2010.

There are over 7,000 agricultural irrigation pump engines in California, representing about 11 percent of the total stationary and portable engine inventory. Because of the high use of these engines, they are a significant source of diesel PM and contribute half of the diesel PM emissions from the entire stationary engine category. In addition, agricultural irrigation pumps tend to be concentrated in specific regions of the State, contributing proportionally higher emissions within these regions.

Although H & SC section 42310(e) prohibits districts from requiring a permit for most equipment used in agricultural operations, districts are not prohibited from establishing emission control requirements for this equipment. Therefore, ARB staff recommends working with the agricultural community to develop a comprehensive program to reduce emissions from engines used in agricultural operations. This program should evaluate both the substitution of diesel engines with electrically driven equipment and a comprehensive retrofit element.

Assuming implementation of this control measure by 2005, ARB staff predicts a reduction of diesel PM from agricultural irrigation pumps of up to 297 TPY by 2010 and 197 TPY by 2020. This represents an 85 percent reduction in diesel PM emissions from at least 90 percent of the engines in this category.

Off-Road Portable

Staff recommends that the ARB develop regulations to reduce diesel PM emissions from existing off-road portable diesel engines. New engines for off-road portable equipment will be regulated by the off-road rules discussed above. The ARB currently administers the Statewide Portable Equipment Registration Program (Statewide Registration Program) Regulation (Title 13 California Code of Regulation §2450 - 2466), which is a voluntary program for the statewide registration and regulation of off-road portable engines. To date, approximately 12,000 off-road portable engines have been registered. The staff recommends that the Statewide Registration Program Regulation be amended to include requirements for reducing diesel PM emissions from portable diesel engines through the application of catalyst-based DPFs, electrification where feasible, and consideration of alternate fuels. In addition, staff recommends the development of an ATCM, for implementation by local districts, consistent with amendments to the PERP regulation. Staff predicts compliance with the ATCM would reduce diesel PM emissions up to 712 tons per year in 2010 and up to 252 tons per year by 2020. This represents an 85 percent reduction in diesel PM emissions from at least 90 percent of the engines in this category.

C. What measures does ARB recommend regarding diesel fuel reformulation?

Table 12 summarizes the recommended measures regarding diesel fuel reformulation. The measures identified in this section are discussed in more detail in Appendix IV.

Table 12: Summary of Recommendations

Recommendation	Emission Reduction (%)	Incremental Cost ($/gal)	Implementation or Issue Date
	Diesel PM		
Very low-sulfur CARB Diesel (≤ 15 ppmw S)	> 90 *	< 0.05	2005-2006
Diesel Fuel Guidance	20 **	< 0.18 **	2001

* Emission reductions with after-treatment.

** Estimated for emulsions of water in CARB Diesel.

ARB staff recommends that a regulation be adopted in 2001 that requires very low-sulfur CARB Diesel for all on-road, off-road, and stationary engines statewide, effective in 2006. The U.S. EPA has published proposed regulations which would require that all diesel fuel sold for use in on-road vehicles have a sulfur content no greater than 15 ppmw, beginning June 1, 2006. It is envisioned that the ARB regulation would apply to on and off road sources but would otherwise be consistent with the U.S. EPA ‘s efforts and enable the retrofit of off-road and stationary diesel engines with catalyst-based after-treatment control technologies.

Also, lower aromatic hydrocarbon and PAH contents and lower fuel-density may help to reduce diesel PM emissions, but we do not know what the benefits would be for the various engines, operational cycles, and levels of after treatment. These fuel specifications should be evaluated for further control benefits.

Synthetic or alternative diesel fuels may cost more than reformulated very low-sulfur CARB Diesel, but should be considered if shown to be cost-effective for diesel PM and other emission reductions. As these alternatives may result in significant benefits for higher-emitting operational categories, such as off-road engines, consideration may need to be given to operational applicability. Synthetic or alternative diesel fuels may prove to be part of the preferred control strategy for diesel-fueled engines or vehicles that result in relatively high risk, or where control retrofit options are very expensive or difficult to implement.

Guidance on diesel fuel options and associated emission reductions should be developed to assist local districts in their permitting of fleets and equipment. The guidance may be especially useful in cases where control equipment retrofits are impractical.

D. What impact will the recommended measures have on diesel PM emissions and risk?

ARB staff estimates the full implementation of the recommended measures will result in an overall 75 percent reduction in the diesel PM inventory and the associated cancer risk for 2010, and an 85 percent reduction for 2020, when compared to today's diesel PM inventory and risk. See Tables 13 and 14. The risk values in Table 13 were estimated assuming that risk is linearly proportional to emissions, which is consistent with the methodology presented in Appendix V.

From 2000 to 2010, ARB staff predicts diesel PM emissions and risk would decrease by only about 20 percent if the recommended measures are not implemented. This reduction would result from the implementation of existing federal and state regulations and the attrition of older diesel-fueled light-duty vehicles and light-duty trucks from the on-road fleet.

The recommended measures can be grouped as follows: measures addressing on-road vehicles; measures addressing off-road engines and vehicles, and measures addressing stationary and portable engines. Table 14 illustrates the impact of each of these groups of measures on projected diesel PM emission levels for 2010 and 2020. As shown, off-road recommended measures have the largest impact. Of the off-road recommended measures, the retrofit measures (see Table 10) have the largest impact, resulting in over 90% of the diesel PM reductions associated with all of the off-road measures.

Table 13: Projected Diesel PM Cancer Risk Levels With and Without ARB Risk Reduction Plan (RRP) Implemented

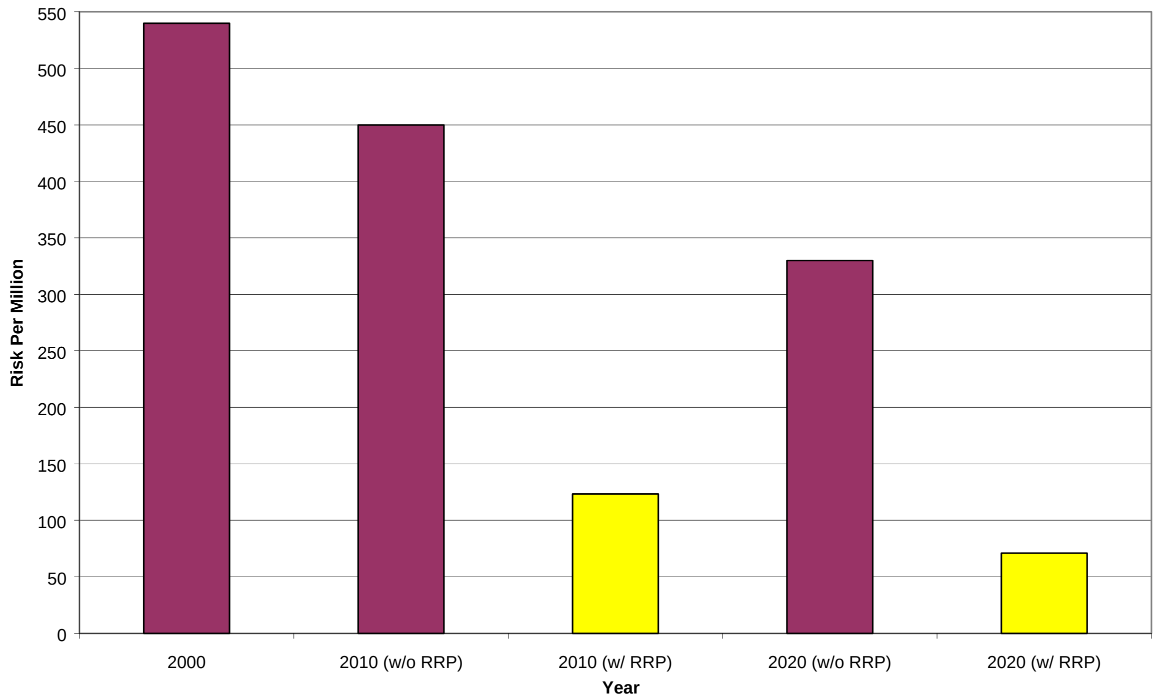
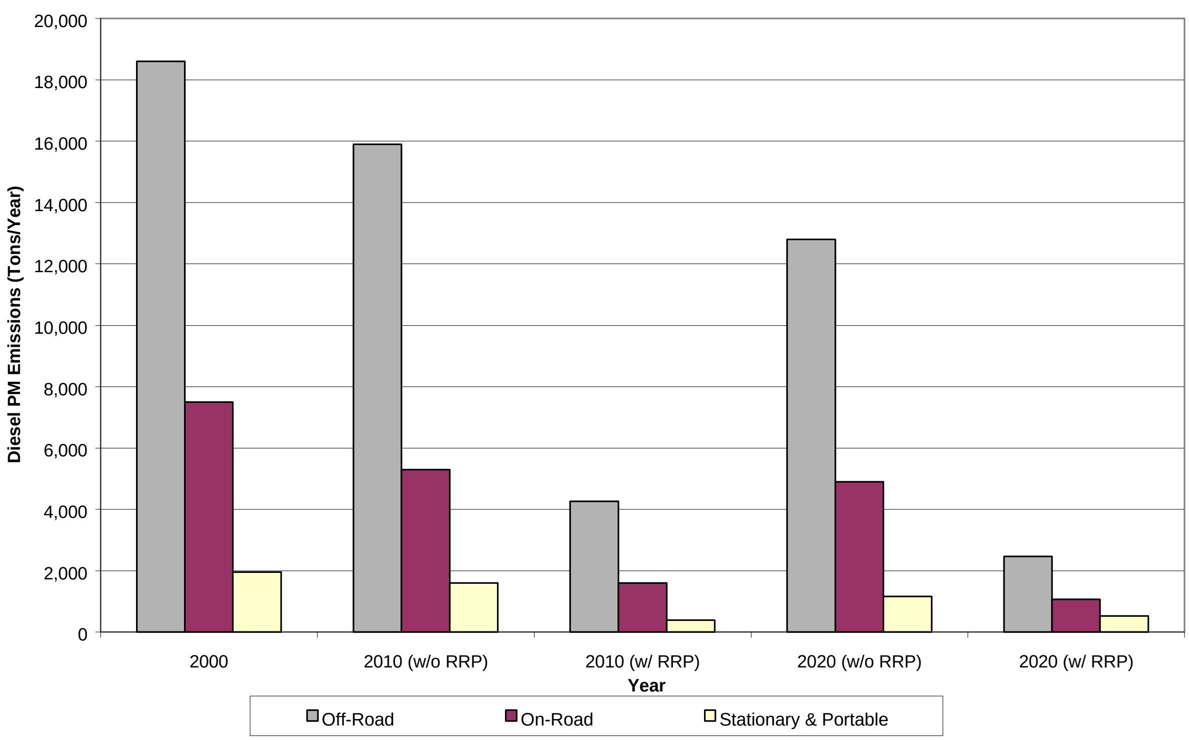


Table 14: Projected Diesel PM Emission Levels With and Without ARB Risk Reduction Plan (RRP) Implemented



E. What other expected benefits are associated with implementing the recommended measures?

As discussed in the previous two sections, full implementing of the measures in this plan will result in significant reductions in diesel PM emissions and associated risk. There are additional benefits associated with reducing diesel PM emissions. These include:

- Increased visibility;
- Less material damage due to “soiling” of surfaces with diesel PM;
- Decreased non-cancer health effects associated with diesel PM;
- Decreased deposits of diesel PM and toxic chemicals on to surface water;

F. What possible adverse impacts may be associated with the recommended measures?

Most recommended measures require the use of add-on control devices, engine modifications, catalysts, low-sulfur diesel fuel and/or alternative fuel formulations. ARB staff has identified possible adverse environmental and safety impacts associated with the recommended measures. Each of these impacts will be fully investigated and addressed during the rulemaking process. Possible adverse impacts are identified below.

- Potential for decrease in fuel economy;
- Potential for increases in emissions of hydrocarbons (HC), oxides of nitrogen (NOx), and carbon monoxide (CO);
- Potential for changes in composition of diesel exhaust that could result in an increase in emissions of other toxic air pollutants.
- Potential for contamination of ground and surface waters;
- Potential safety issues due to use and handling of gaseous-fuels; and
- Potential increase in hazardous waste from the disposal of spent catalyst material.

G. What actions should the U.S. EPA pursue to support the ARB staff's recommended measures?

ARB staff recommends that the U.S. EPA adopt standards and regulations applicable to all 50 states that are similar in both scope and stringency to the measures in this plan. Further, ARB staff recommends the U.S. EPA take the following actions to support the measures in this plan and to reduce diesel PM emissions nationwide.

- *The U.S. EPA should implement more stringent emission standards for diesel PM in the Tier 3 rule making than are currently envisioned in the Off-Road Statement of Principles.*

Currently, the federal Clean Air Act preempts California from regulating new construction and farm equipment below 175 horsepower, new locomotives and locomotive engines, and commercial marine engines. Preempted off-road vehicles and equipment generate approximately 60 percent of the diesel PM emissions from off-road sources, thus limiting California's ability to achieve significant emission reductions on its own. Recent developments suggest that off-road engine control can move directly to aftertreatment technology-based standards with higher emission reductions, on a cost-effective per engine basis. U.S. EPA should, therefore, consider the proposal (see Appendix III) to accelerate the implementation of emission standards based on aftertreatment technologies with the goal of reducing diesel PM emissions by 90 percent from engines in these categories.

- *Require all diesel-fueled on-road and off-road engines and vehicles to use very low-sulfur diesel fuel ($\leq$15 ppm).*
  The U.S. EPA has published regulations that would require all very low-sulfur diesel fuel to be sold for use in on-road vehicles only beginning June 1, 2006. ARB staff's recommended measures for off-road engines are based on the use of very low-sulfur diesel fuel and the use of exhaust after-treatment devices. As such, it is critical that very low-sulfur diesel fuel be required to be sold nationwide for use in off-road engines and vehicles. If not, California-only off-road regulations should be developed, but issues concerning the cost-effectiveness of developing California-only engine/after treatment systems and the compatibility of those systems with a higher sulfur national off-road diesel fuel need to be explored.

- *U.S. EPA should require more stringent control of PM emissions from commercial marine vessels through retrofit of existing engines.*
  Emissions from commercial marine vessels, which includes ocean-going vessels, tugboats, fishing boats, cruise ships, and other large ships, are a major source of diesel PM which is expected to grow from 2000 to 2010. A program to retrofit existing engines could provide significant benefits over the adopted controls for new engines recently adopted by U.S. EPA. The U.S. EPA should, therefore, develop standards to reduce diesel PM emissions from these engines.

- *U.S. EPA should require the implementation of a retrofit program to reduce diesel PM from locomotives.*
  The current national rule only affects particulate matter emissions from model year 2005 and later locomotives and does not reduce PM emissions from older locomotives. Recent developments in diesel particulate filter technology suggest that a locomotive retrofit program may be feasible and cost-effective.

The U.S. EPA should, therefore, develop retrofit standards to reduce diesel PM emissions from engines in these categories.